campanulate corollas. One is tempted to interpret it as being of hybrid origin, an interpretation nicely supported by the orientation of the marginal hairs on the leaves. *Galium mexicanum* in general has usually many stout retrorse prickles on the leaf margins. In *G. concinnum,* however, although the leaves are nearly glabrous, such hairs as can be found are antrorse. In *G. mexicanum* ssp. *flexicum,* the situation is intermediate, the relatively slender hairs on the basal half of the leaf being basally directed, and those on the apical portion being apically directed. The presence of hairs on the ovaries is considered to be critical in assigning ssp. *flexicum* to *G. mexicanum* rather than to *G. concinnum.*

The Palmer collections from the Limpia Canyon, Jeff Davis Co., differ from those of the Del Carmen and Chisos mountains only in that the marginal leaf-hairs are a little stouter and all basally directed. On the other hand, they differ sharply from plants of Mt. Livermore and elsewhere in the Davis Mountains, all of which are clearly ssp. *mexicanum.*

I thank Rimo Bacigalupi for editing the Latin.

VEGETATION SURROUNDING KINGS LAKE BOG, WASHINGTON

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This communication describes vegetation surrounding a small bog lake in lowland King County, Washington. We tested the hypothesis that the plants comprising vegetation surrounding this bog are arranged in zones rather than continuously in response to environmental gradients.

Vegetation can be analyzed by two distinct approaches. Numerical classification methods group samples into categories and emphasize similarities within and differences between categories. Ordination methods arrange samples sequentially based on environmental data or on compositional similarity of the vegetation itself or both. Both methods can contribute to the understanding of vegetation and the causes of vegetation organization.

Gauch and Whittaker (1972) documented the growing realization of many ecologists that simple geometric ordinations are superior to more elegant methods in several ways. They are mathematically straightforward and the results are usually more reliable. Ordination approaches have been successfully applied to many situations but seem best adapted to those in which beta diversity is low and vegetation scale being investigated is intermediate (Gauch, 1973).

Vegetation classification has a venerable history with many "traditions" (Shimwell, 1973; Mueller-Dombois and Ellenberg, 1974) that will not be reviewed here. We favor methods that emphasize dominants rather than differential or character species. We selected an agglomerative hierarchical method devised by Orloci (1969) based on comparisons of information gained when two groups are merged and that produces a dendrogram. This method is superior to non-hierarchical numerical classification methods (Williams, 1971).

All hierarchical classifications are plagued by the problem of termination; analysis proceeds until all samples are placed into a single group. The investigator must intuitively determine when joining groups should cease. Del Moral (1975) proposed a solution to this problem by using stepwise discriminant analysis. Clustering terminates when as many or more groups are recognized by the classification as are tentatively thought to occur in the field. Discriminant analysis assesses statistical differences between groups, reallocates individual samples if necessary, and indicates the relative importance of species in constructing the classification.

Kings Lake Bog lies in the western foothills of the Cascade Mountains (N47°35′40″, W 121°46′35″), at 280 m, well within the *Tsuga heterophylla* zone in the Puget Trough (Franklin and Dyrness, 1973). Kings Lake is 1.1 ha and is surrounded by a 21 ha bog. It is 4.6 m deep off the mat edge (Wolcott, 1973). The surrounding forest was logged and burned in the 1930's by the Weyerhaeuser Company, upon whose land the lake is located (Fitzgerald, 1966).

The area we sampled extends from the floating mat edge to a portion of the surrounding forest (fig. 1). A lagg (Oswald, 1933) borders the east and southeast lakeside; it is covered by fallen logs and abruptly joins higher ground. *Spiraea douglasii* occupies much of this area. The remaining sides of the bog exhibit a more gradual change in forest and our sample was confined to this zone of transition.

Fitzgerald (1966) showed that the microclimate of the open bog was more extreme than that of the surrounding forest. Temperature extremes varied annually from 43° C to − 17° C on the bog and from 21° to 6° C in the forest. Diurnal variation, due to more insolation and intense reradiation, was much greater on the bog than in the forest. For example, in one 24 hr period in July, 1965, temperature varied 20° C on the bog compared to 6° C in the forest. The bog experiences many more days of sub-freezing temperature than the surrounding forest. The water table fluctuates such that during early spring, standing water may be found above the moss layer throughout the bog while in late summer the mat is very dry. By these climatic criteria, the bog habitat is more severe than the forest.

Methods

Vegetation sampling. We sampled vegetation along a 216 m by 10 cm line intercept transect from the mat edge into forest. Within alternate

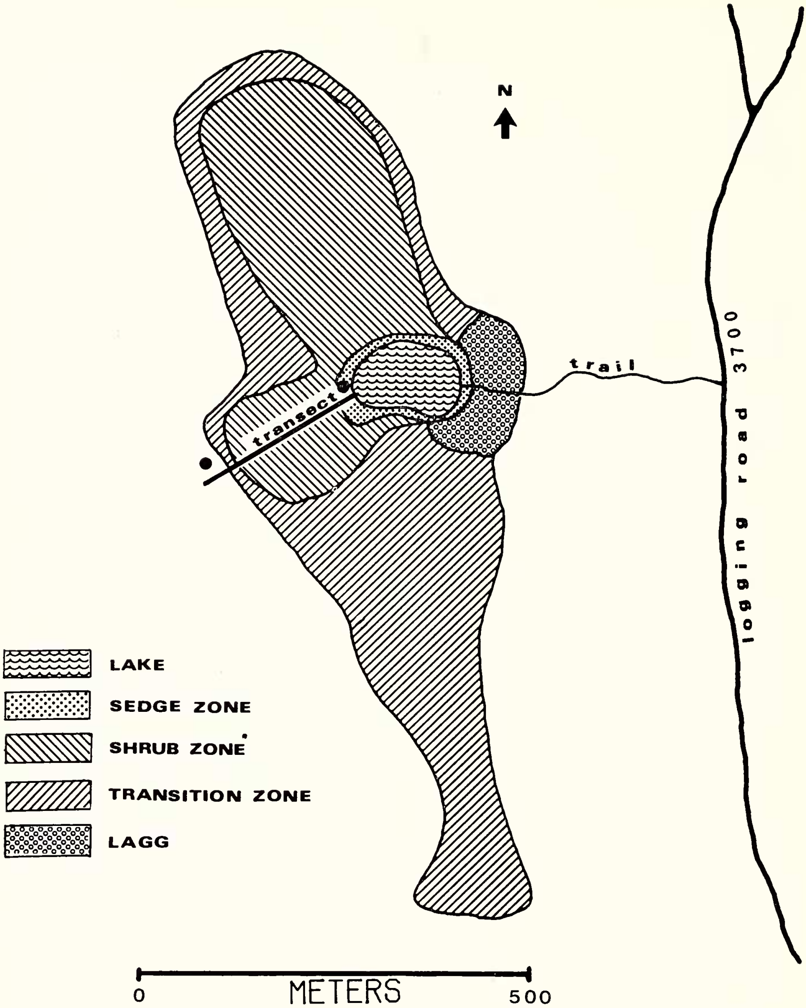

FIG. 1. Vegetation zone map of Kings Lake Bog showing location of access trail and transect. Forest is unshaded.

1 m segments, we recorded leaf intercept at each centimeter. The bog contains hummocks between the forest and the floating mat. In order to reduce sampling errors inherent in such heterogeneous communities, cover was expressed as the percentage of centimeter occurrences per meter. We did this because we were not interested in microtopographic patterns, which we observed on a scale of a few centimeters. Sampling error is fairly high for rare species but lower for common species. A preliminary study compared 1 m^2 quadrats with line intercept values and

gave similar results (means and standard deviations). The analyses reported here are confined to 14 more common species.

Quantitative analysis. Percent cover for the 14 dominant species was used in our analyses. Orloci's (1969) mutual information method was implemented with a computer program modified from Goldstein and Grigal (1971). The matrix is inspected for local minima and the corresponding subsets are united to form new groups with minimum information gain. The results are displayed by a dendrogram that shows the mutual information at which each subset is joined.

Once tentative groups are identified tests of significance of group differences and tests of group membership are accomplished with stepwise multiple discriminant analysis (SMDA). Mathematical details are found in del Moral (1975), who followed Dixon (1970). Given a partitioned set of data, SMDA determines the order in which variables (species) are useful to distinguish between groups. At each successive step an F-test for differences between groups is made. Individual samples are evaluated to determine the class to which they belong. This permits an *a posteriori,* objective, reallocation of the samples. The phytosociological relationships among the groups are determined by means of canonical rotation of the discriminant axes. What results is a set of mutually orthogonal (independent) axes in which variation is maximized on the first axis. Samples are plotted according to the first two canonical axes, thus providing an optimum two-dimensional picture of the relationships between groups.

We also used similarity projection ordination (Gauch and Whittaker, 1972) to determine vegetational relationships. This is a multidimensional extension of the polar ordination method of Bray and Curtis (1957). To effect an ordination, we selected two samples that contrasted strongly. Several trials, based on the similarity matrix, were used. We selected an internal association of 90 percent arbitrarily since a) published values vary from 80 to 100 percent and b) Gauch and Whittaker (1972) concluded that internal association has little effect on rank order in ordinations. All other samples are projected orthogonally onto the axis defined by the end stands. A second axis was defined by stands chosen with the following criteria: stands from the center of the first axis, stands quite dissimilar to each other, and stands distinct from the first axis. Additional dimensions did not improve the ordination.

Results and Discussion

Qualitative Description. Prior to selection of transect location, a general survey was made. Fitzgerald (1966) divided this bog subjectively into five zones. We added the lagg area and classified samples of vegetation into one of the six zones and recorded species composition. Table 1 provides a qualitative list of species encountered in each zone. Nomenclature of vascular plants follows Hitchcock and Cronquist (1973), moss nomenclature follows Lawton (1971), and lichen nomenclature follows Hale (1969).

Table 1. Occurrences of All Taxa Encountered in Six Zones Around Kings Bog. F = forest, T = transition zone, S = shrub zone, Se = sedge zone, L = lagg, P = pioneer zone. Species used in quantitative analysis are marked *.

	Vegetation zone					
Taxon	F	T	S	Se	L	P
*Tsuga heterophylla	X	X	X		X	X
Thuja plicata	X	X	X		X	
Picea sitchensis	X				X	
Pseudotsuga menziesii	X				X	
Acer circinatum	X				X	
*Ledum groenlandicum		X	X		X	X
*Kalmia occidentalis		X	X		X	X
*Vaccinium oxycoccus		X	X	X	X	X
Vaccinium alaskense	X	X	X		X	
Vaccinium ovalifolium	X	X			X	
Vaccinium parvifolium	X				X	
Spiraea douglasii		X			X	
*Gaultheria shallon	X	X	X			
Menziesia ferruginea	X					
Rubus spectabilis	X					
Sambucus racemosa	X					
Symphoricarpos occidentalis					X	X
Maianthemum dilatatum	X	X			X	
*Cornus canadensis	X	X			X	
Pyrola uniflora	X					
Circaea alpina	X					
Montia sibirica	X					
Galium aparine var. echinospermum	X					
Actaea rubra	X					
Corallorhiza sp.	X					
Listera sp.	X					
Lycopodium annotinum	X					
*Pteridium aquilinum var. pubescens	X	X	X			
Trientalis arctica					X	
Agrostis oregonensis					X	
Potentilla palustris					X	X
Nuphar polysepalum			X		X	
Menyanthes trifoliata				X	X	X
Drosera rotundifolia				X		X
Carex cusickii			X	X		X
Carex vesicaria			X	X		X
Juncus ensifolius			X	X		X
Juncus effusus var. compactus			X	X		X
*Rhynchospora alba				X		X
Cicuta douglasii						X
Lysichitum americanum		X	X	X	X	
Polysticum munitum	X					
*Cladonia rangiferina			X	X		
Usnea longissima	X	X	X		X	
*Sphagnum subsecundum		X	X	X	X	X
*Pleurozium schreberi		X	X		X	
Rhytidiadelphus triquetrus	X		X			
Aulacomnium androgyne	X		X			
Polytrichum juniperinum	X		X			

TABLE 1. *Continued.*

*Hylocomnium splendens	X	X				
*Eurhynchium praelongum var. stokesii	X					
Isothecium stoloniferum	X					
Dicranum sp.	X					
Bryum sp.	X					
Total numbers	33	17	21	11	24	15

Each vegetation zone is recognized by both dominants and physiognomy. Aspect zonation around the lake is clear. At the edge of the sphagnum mat is a peat-sedge zone in which dominance is shared by *Rhynchospora alba, Vaccinium oxycoccus,* and *Cladonia rangiferina.* A shrub zone dominated by *Ledum groenlandicum, Kalmia occidentalis,* and stunted *Tsuga heterophylla* borders the first zone. This mounded zone is heterogeneous with mounds and intermounds having different species composition. Intermounds are dominated by *Sphagnum subsecundum* and *Pleurozium schreberi.* The forest proper rises abruptly from the edge of the shrub zone.

Closer inspection reveals additional distinct areas. Between the sedge zone and the lake lies a very narrow band consisting of two phases and termed the pioneer zone: *Ledum groenlandicum, Kalmia occidentalis,* and *Potentilla palustris* form a matrix extending into the lake. Within this matrix may be found *Sphagnum subsecundum* and *Drosera rotundifolia.*

Within the sedge-peat zone, considerable seasonal variation in aspect dominance occurs. *Rhynchospora* dies back to an underground rhizome annually. *Cladonia* is sporadic. While numerous, *Vaccinium oxycoccus* has low cover. All of these are obscured by *Rhynchospora* during spring and summer.

The shrub zone maintains its appearance throughout the year since the dominants are evergreen and form a dense intertwined layer. The mat layer beneath the shrubs consists of *Vaccinium oxycoccus, Sphagnum subsecundum, Cladonia rangiferina,* and *Pleurozium schreberi.* Punctuating this mat are sporadic *Lysichitum americanum* individuals in depressions. Pools of various sizes also occur and are dominated by *Juncus effusus, J. ensifolius* var. *compactus, Carex cusickii,* and *C. versicaria,* all of which also occur in the sedge zone. (These pools were not sampled by the intercept transect.)

The forest shrub transition zone is an interdigitation of forest and shrub zone species. *Pteridium aquilinum* var. *pubescens* and *Gaultheria shallon* extend farther into the shrub zone than other forest species. *Vaccinium alaskense* and then *V. ovalifolium* are encountered as the hemlocks gain stature. *Cladonia rangiferina* and *V. oxycoccus* are the first bog species to disappear. *Sphagnum subsecundum* and *Pleurozium schreberi* are replaced gradually by *Hylocomnium splendens, Eurynchium* *praelongum,* and *Rhytidiadelphus triquestrus.* Within the forest, the terrain is level and species common to *Tsuga heterophylla* forests occur (Table 1).

The lagg is a special type of vegetation that does not extend completely around the bog. It is richer in species than all but the forest zone. *Spiraea douglasii, Lysichitum americanum,* and *Symphoricarpos occidentalis* are among the common species.

While most species on the bog display regular patterns with respect to the major environmental gradients associated with the degree of "bogginess", some occur sporadically in response to the presence of water pools.

Lysichitum americanum is sporadic throughout the bog from mat edge to forest margin. Turesson (1916) believed that *Lysichitum* was relictual, maintaining itself by shading and mechanically destroying *Sphagnum,* the main invader. Each individual *Lysichitum* is rooted in a deep hollow, the edges of which may be lined with forest moss species such as *Aulacomnium androgyne, Rhytidiadelphus triquetrus,* or *Polytrichum juniperinum.* Turesson's hypothesis does not explain the presence of *Lysichitum* in the hanging mat.

Many individuals of *Lysichitum* are found in the lagg, which is similar to its usual swampy habitat. Pools may be formed in the mat by various disturbances, including wind throw of adjacent trees and trampling by man or beast. These pools may be invaded and enlarged by *Lysichitum.* Therefore, we believe that *Lysichitum* invades disturbed bogs. Its density is being monitored annually to test this hypothesis.

Other species occur in atypical patterns in this bog. Most patterns are due to the presence of the lagg or to downed timber creating less boggy conditions and variable seed beds. Species such as *Nuphar polysepalum* and *Menyanthes trifoliata* occur in pools in the mat even though these are usually considered lake margin species. Where fallen logs occur, forest understory species invade to the edge of the lake. Thus *Vaccinium parvifolium, Cornus canadensis,* and *Maianthemum dilatatum* occur on rotting logs at lake margin. These species often occur on fallen logs in the forest and such a distribution is not surprising.

Zones viewed on the basis of dominant species are identified in the field. However, our fundamental question is not whether zones can be distinguished subjectively. Several generations of ecologists have demonstrated that this is possible and useful. We wished to determine if such subjective zones maintain their discreteness in the face of an objective analysis.

Quantitative Description. The location of the transect with respect to a vegetation map of Kings Lake Bog, which emphasizes zonation, is shown in Figure 1.

Dendrogram. We clustered 108 samples by MINFO (Goldstein and Grigal, 1971). The dendrogram (fig. 2) confirms the validity of the zonation concept when dealing with dominant vegetation. Sample numbers across the bottom of Figure 2 are the sequence in which samples

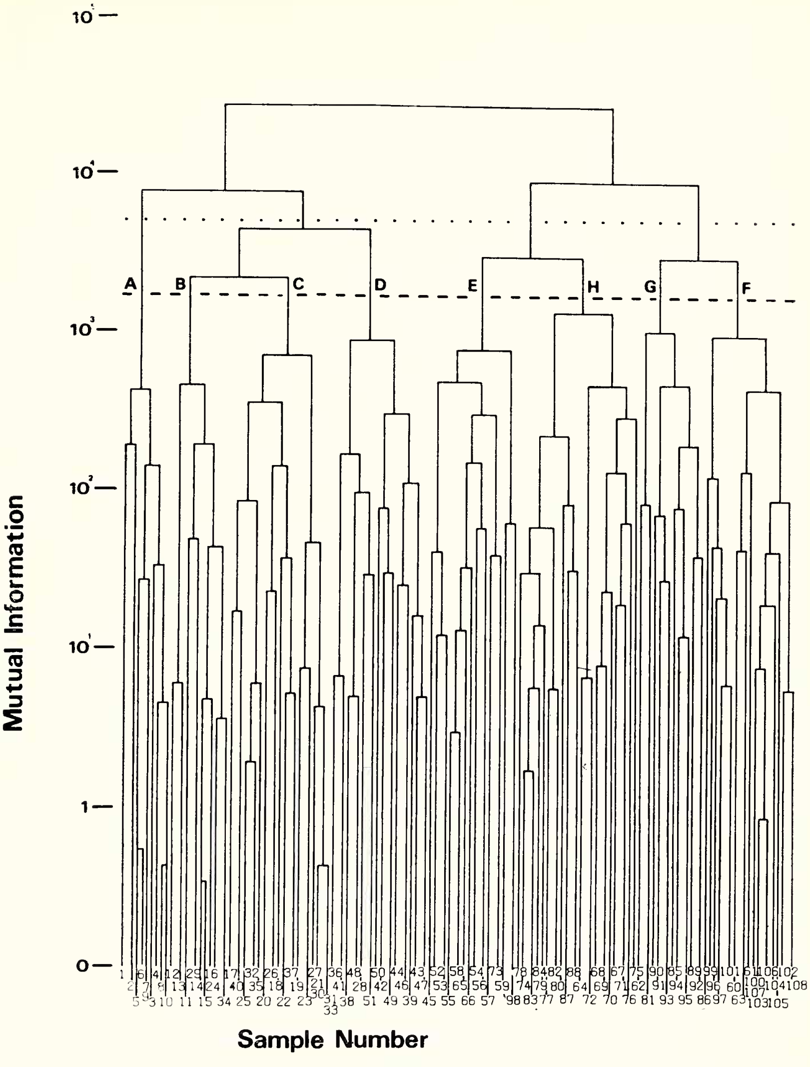

FIG. 2. Dendrogram produced by MINFO. Letters indicate the eight groups used in subsequent analyses. The dotted line (5×10^3) indicates the level of similarity required to produce four zones. Sample numbers are sequence in the transect.

were encountered from the Lake to the forest. If clustering is terminated at the 5×10^3 level of mutual information (dotted line), then four groups, corresponding to the sedge zone, the shrub zone, the transition, and the forest, are recognized. Termination at 2×10^3 (dashed line) results in the eight groups labeled in Figure 2. Some features not ordinarily noted in dendrograms emerge from a consideration of this one. In the dendrogram, sample similarity is indicated by the level of first joining. The degree of sample similarity appears highest in the sedge zone, least in the transition, and intermediate in the others. Thus, the dendrogram produces classes but simultaneously differential relationships between samples imply a gradational pattern.

Discriminant analysis. The eight subsets were investigated by stepwise discriminant analysis to determine whether any samples should be reallocated, to determine whether any pair of clusters should be merged, to determine the relationship of the groups to each other, and to determine the relative importance of species. In Table 2 we list the order in which species were used to distinguish among the classes. The two most important species distinguished between forest and sedge zones, the third is primarily a shrub zone species, and the fourth is a transition zone species.

After 14 steps, the eight groups are all highly statistically significantly different ($P < 0.01$, d.f. = 14, 87). Six samples are reallocated by this analysis, four transferring samples from C to B. The final F-table (Table 3) indicates that clusters B, C, and D are closely related. These three are united by *Ledum* dominance, but D has high cover of *Pleurozium schreberi,* while B and C are distinguished on the basis of *Vaccinium oxycoccus*. Cluster A can be recognized by dominance by *Rhynchospora* and *Cladonia*. Clusters F, G, H, and E belong to the forest and transition. Clusters E and H are related on the basis of *Pleurozium* and *Ledum*. Cluster F is distinguished by high concentrations of *Hylocomnium* and *Pteridium,* while G is a mixture dominated by *Pteridium*. Cluster H lacks *Tsuga* and is characterized by *Pteridium, Pleurozium,* and *Ledum,* while E is dominated by *Gaultheria, Ledum,* and *Pleurozium*. The den-

TABLE 2. RANK ORDER OF SPECIES DETERMINED BY DISCRIMINANT ANALYSIS. F-value indicates the relative information and degree of significance with 7 and 87 degrees of freedom.

Step Number	Species	F-valule	P of Larger F-value
1	Hylocomnium splendens	130.5	0.005
2	Rhynchospora alba	111.9	0.005
3	Kalmia occidentalis	65.7	0.005
4	Pleurozium schreberi	24.1	0.005
5	Cladonia rangiferina	13.5	0.005
6	Gaultheria shallon	12.7	0.005
7	Ledum groenlandicum	15.7	0.005
8	Pteridium aquilinum	8.1	0.005
9	Sphagnum subsecundum	6.9	0.005
10	Eurhynchium praelongum	4.4	0.005
11	Maianthemum dilatatum	2.3	0.05
12	Vaccinium oxycoccus	2.3	0.05
13	Cornus canadensis	1.3	n.s.
14	Tsuga heterophylla	1.0	n.s.

TABLE 3. F-VALUES BETWEEN PAIRS OF GROUPS (see fig. 2). Degrees of freedom = 14, 87. Values exceeding F = 2.28 occur between two sets of samples from the same group with $P < 0.01$.

A							
46.885	B						
61.448	6.663	C					
63.061	10.438	6.877	D				
60.626	20.405	24.163	17.483	E			
78.285	54.639	72.073	72.591	49.955	F		
38.051	27.907	32.868	34.340	29.836	24.937	G	
59.262	25.696	27.919	25.254	12.389	55.365	19.449	H

drogram tends to confirm the impressions produced by the F-table. Here, A joins B, C, and D at a high level of information. B and C are closely related and D is more closely related to these than to others. The affinity of E and H is demonstrated as is that of F and G. E is intermediate between H and D and closer to H by F-test as is confirmed by the dendrogram.

Discriminant analysis includes a determination of canonical axes. The first canonical axis accounts for 41.7 percent of the variation while the second accounts for 21.2 percent; both axes have high correlation with the discriminant axes. Figure 3 is a two dimensional plot of the canonical distribution of samples. This plot reconfirms our conclusions concerning the relationships among the eight groups. B, C, and D are shown to be closely related, E and H are relatively close, F and G are more distinct and A is very distinct. A, F, and G are all loosely defined groups. Group A is in the sedge zone and F is in the forest zone, suggesting that some rotation of these axes represents an approximation of the original transect that is a gradient of nutrient availability and soil oxygen content (Lebednik, unpublished).

Key to Vegetation Clusters. The discriminant analysis provides information to produce a key to the vegetation types recognized. Our key uses those species highest in the rank order of information. In Table 4 we list the composition of the eight groups according to the zonation perceived subjectively. The following key may be used to identify these types in the field:

a. *Rhynchospora alba* dominant (Sedge Zone) . . . . . Type A
aa. *Rhyncospora alba* rare or absent, Ericaceous shrubs common
  b. *Kalmia occidentalis* dominant (Shrub Zone)
    c. *Pleurozium schreberi* over 25% cover . . . . . Type D
    cc. *Pleurozium schreberi* rare or absent
      d. *Sphagnum subsecundum* common . . . . Type C
      dd. *Sphagnum subsecundum* absent, *Cladonia rangiferina* common . . . . Type B

bb. *Kalmia occidentalis* rare or absent
e. *Pleurozium schreberi* over 50%, or if less, then *Ledum groenlandicum* common (Transition zone)
f. *Pteridium aquilinum* common . . . . Type H
ff. *Pteridium aquilinum* rare . . . . Type E
ee. Both *Pleurozium schreberi* and *Ledum groenlandicum* rare (Forest Zone)
g. *Gaultheria shallon* and *Hylocomnium splendens* common . . . . Type F
gg. *Pteridium aquilinum* dominant, others mixed . . Type G

Similarity Projection Ordination. The dendrogram suggests greater continuity in the data than is manifest by classification approaches. Simi-

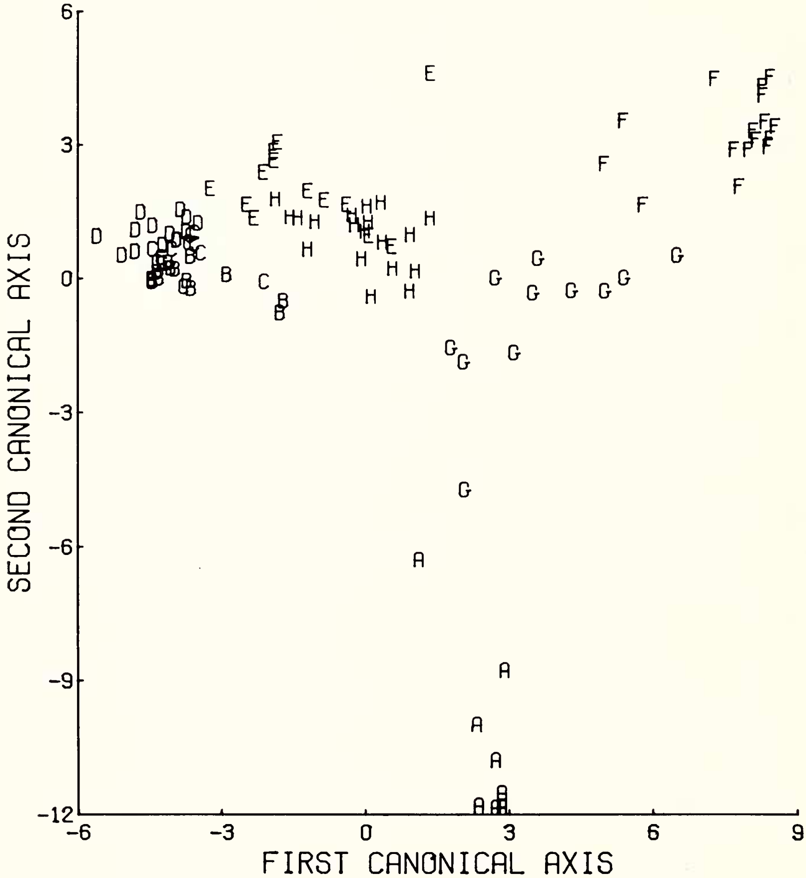

Fig. 3. Canonical distribution of the eight groups determined by discriminant analysis. Letters refer to groups in Figure 2.

TABLE 4. MEAN COVER PERCENTAGE OF DOMINANT SPECIES FOR THE EIGHT REVISED GROUPS IDENTIFIED IN MINFO.

Taxon	Cluster								Transect Mean
	A	B	C	D	E	F	G	H	
Ledum groenlandicum	1.0	99.2	97.6	99.2	67.3	4.2	4.0	41.8	53.0
Kalmia occidentalis	4.9	85.0	90.3	84.6	6.2	0.9	0.0	5.6	34.2
Vaccinium oxycoccus	15.2	5.0	65.6	50.4	0.0	0.0	0.0	0.0	18.6
Rhynchospora alba	80.3	0.0	0.1	0.0	0.0	0.0	0.0	0.0	7.4
Sphagnum subsecundum	0.0	0.0	58.2	8.6	2.3	5.0	1.0	28.9	16.5
Pleurozium schreberi	0.0	4.9	0.0	75.6	78.8	2.5	14.0	65.3	32.8
Cladonia rangiferina	38.0	78.0	12.8	5.0	0.8	0.0	0.0	0.0	13.3
Tsuga heterophylla	0.0	23.3	3.6	15.0	0.8	0.9	13.5	0.0	5.8
Gaultheria shallon	0.0	0.0	0.0	3.2	77.3	73.7	14.0	49.5	30.6
Pteridium aquilinum var. pubescens	0.0	0.0	0.0	0.2	5.2	22.8	64.0	77.6	23.6
Hylocomnium splendens	0.0	0.0	0.0	0.0	5.8	92.5	22.0	0.8	16.8
Eurhynchium praelongum	0.0	0.0	0.0	0.0	0.0	0.3	21.5	0.0	2.0
Cornus canadensis	0.0	0.0	0.0	0.0	3.8	3.8	4.0	0.3	1.4
Maianthemum dilatatum	0.0	0.0	0.0	0.0	0.0	0.3	3.0	0.0	0.3

larity projection ordination was used to determine whether a continuum approach recognizes the community types reported above.

The first axis is defined by samples 32 (a member of group C) and 97 (group F) and the second axis is defined by samples 10 (group A) and 67 (group H). The first axis represents shifts within shrub dominated vegetation and the second in non-woody dominated vegetation. The resultant ordination is shown in Figure 4, in which previously recognized communities are circumscribed. The rate of change of species (beta diversity) along the first projection axis is relatively large so that there is distortion of the type reported by Gauch (1973) in his analysis of Bray-Curtis polar ordination, to which Similarity Projection Ordination is closely related. Samples toward the middle of the first projection axis tend to be distant from it so that there is a "hump" in the analysis. This hump results because Percent Distance is not a linear estimator of ecological relationships between the samples.

Ordination suggests that, with the exception of type A, the *Rhynchospora* dominated community, the data are continuous. The *Rhynchospora* community is unique by virtue of the virtual absence of erect shrubs. Communities B, C, and D, which are closely related in the classification hierarchy, are likewise clustered in the ordination and linked by cover of *Ledum* and *Kalmia*. Communities F (*Gaultheria/Hylocomnium*) and G (*Pteridium/Hylocomnium-Eurhynchium*) are distinct (except for sample 93) and can correctly, if arbitrarily, be separated from each other and from E (*Gaultheria/Pleurozium*) and H (*Pteridium-Gaultheria/Pleurozium*). However, communities E and H, which are as

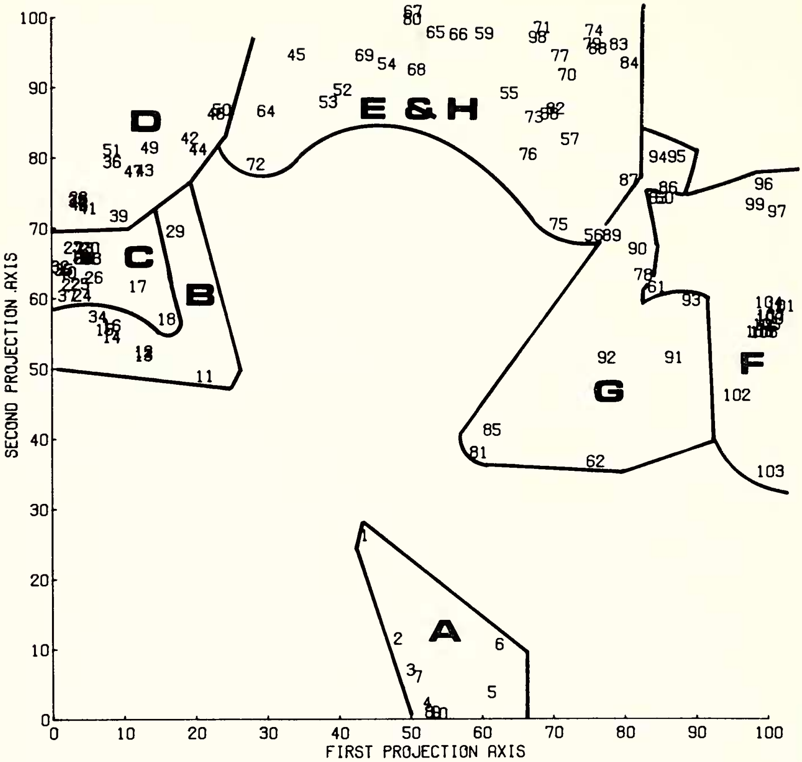

FIG. 4. Similarity projection ordination using samples 32 and 97 as end points for the first axis and samples 10 and 67 for the second. Samples representing the eight groups revealed by MINFO (A–H, see fig. 2) are circumscribed.

related to each other as are F and G, are scrambled in the middle of axis one at the upper end of axis two. These samples occur in a transition zone, show little tendency to cluster, are well separated from other samples, and are intermixed. The ordination reflects the classification better at the four group level than at the eight group level.

Although similarity projection and discriminant analysis are entirely different analytical tools, they produce similar results (cf. figs. 3 and 4). All groups occupy similar relative positions though spacing is distorted due to different mathematical assumptions. Community type G is plotted lower on the second canonical axis in relation to F than in similarity projection. In both, the integradation of E and H is evident though it is more pronounced in the similarity projection.

Comparison of Classification and Ordination. The two approaches of this study reveal that while the vegetation can be treated as four vegetation zones, the continuum approach suggests the gradient nature of the vegetation. The vegetation may be classified numerically by a method that stresses dominance types, and the resultant classes can be recognized in an ordination. However, canonical analysis of these types reveals considerable variation within a type and continuity between seven of the eight types. Since we obtained this result with only 14 common species, we believe that this conclusion applies even more strongly to cases of greater species richness.

Fitzgerald (1966) studied this bog by means of relevés in the style of Braun-Blanquét. She discerned the four zones we have retained in our discussions. Our methods suggest that greater complexity of community pattern exists. They also recognize that the classes, with one exception, are arbitrary modes in an essentially continuous pattern.

Conclusions and Summary

The vegetation of Kings Lake Bog has been described by classification and ordination methods. The question posed by this study was whether vegetation forms distinct zones around this bog or whether it forms a continuous pattern. Combined analyses suggest that vegetation forms a gradient except for one distinct type, distinguished by *Rhynchospora alba* and several other sedge species. This type occurs on the most exposed portion of the floating mat where woody ericacous shrubs have not invaded. Zones may be recognized in the remaining portions of the gradient from lake to forest, but these zones reflect only the distribution of dominant species. Our classification constructed more communities than were recognized by Fitzgerald (1966) and discriminant analysis suggests that these form a nearly continuous sequence.

The combined use of classification and ordination methods in this study reveals a correlation between philosophically contrasting approaches. The similarity between canonical distribution of samples and similarity projection analysis is striking when one considers the disparate mathematical approaches. For mapping and synthesis of vegetation data, we recommend numerical classification methods such as MINFO. The use of discriminant analysis to refine resultant classifications provides a means for objective reallocation of samples and for assessing the validity of each group. Where the behavior of individual species is important, then ordination methods are superior. Ordinations may be divided into segments for ease of consideration, but we propose that such partitioning be done on the basis of numerical classification methods.

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NOTES AND NEWS

Fly Pollination of Penstemon davidsonii and P. procerus (Scrophulariaceae).—Agents implicated as pollinators of various species of *Penstemon* include: hummingbirds, coleopterans, carpenter bees, honeybees, bumblebees, solitary bees, masarid wasps, bee flies, syrphid flies, moths, and many other hymenopterans, dipterans, and lepidopterans (references below and: Clements and Long, Publ. Carnegie Inst. Wash. 336, 1923; Cooper, Amer. Midl. Naturalist 48:103–110, 1952; Merritt, Erythea 5:15–22, 1897; Robertson, Trans. Acad. Sci. St. Louis 25:277–324, 1927, *Flowers and insects,* 1928; Straw, Evolution 9:441–444, 1955 Amer. Naturalist 90:47–53, 1956). Heretofore, fly pollination of *Penstemon* has been described in